CHAPTER 4

BLUEPRINT READING AND TECHNICAL DRAWINGS

Blueprints, sometimes called prints, are reproduced copies of mechanical or technical drawings. Drawing or sketching is the universal language used by engineers, technicians, and skilled tradesmen.

The term *reading print* is defined as the ability to interpret the ideas of others expressed on drawings and sketches. This chapter has been developed to give you some insight into the preparation and use of blueprints.

DEVELOPMENT OF CONSTRUCTION DRAWINGS

Drawings are generally categorized according to their intended purposes as follows:

- Preliminary drawings
- Presentation drawings
- Shop drawings
- Working drawings

PRELIMINARY DRAWINGS

A building project may be broadly divided into two major phases: the design phase and the construction phase. Preliminary drawings are prepared by the A and E (architects' and engineers') firm during the design phase to promote building development. These drawings are used for exploring design concepts between the designer and the user (customer), making material selection, determining preliminary cost estimates, and as a basis for preparing the finished working drawings.

PRESENTATION DRAWINGS

Presentation drawings show the proposed building or facility in an attractive setting in its natural surroundings at the proposed site. Since presentation drawings are actually used to sell an idea or a design, your only contact with such drawings will be as a cover sheet for a set of construction drawings.

SHOP/WORKING DRAWINGS

After approval has been given for construction, the shop and working drawings are developed. Throughout your career, you will hear these drawings referred to as construction drawings, prints, or plans. Basically, these terms are all correct; they can be used interchangeably.

As mentioned earlier, the construction drawings are developed from the preliminary drawings. With the collaboration of the designer or the architect and the engineer, both the materials to be used and the construction methods to be followed are decided. The engineer determines the loads that the supporting (structural) members will be required to bear and then designs the mechanical systems for the structure; for example, heating, power, lighting, and plumbing.

You will find the construction drawings, the specifications, and the bill of material (BM) your chief source of information during the construction phase of the project.

BLUEPRINT READING

There are several reasons for having construction drawings and why you need

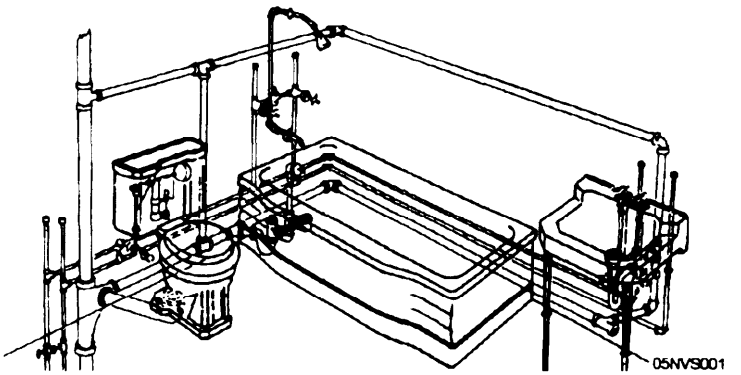

Figure 4-1(A).—Pictorial view of a typical bathroom.

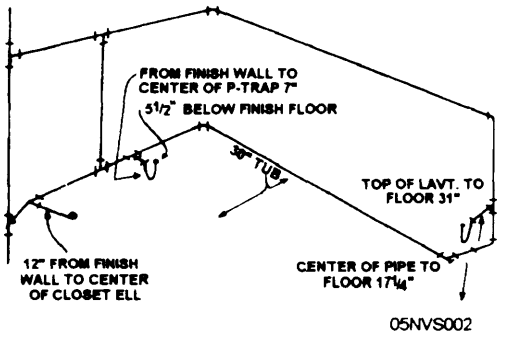

Figure 4-1(B).—Waste and vent.

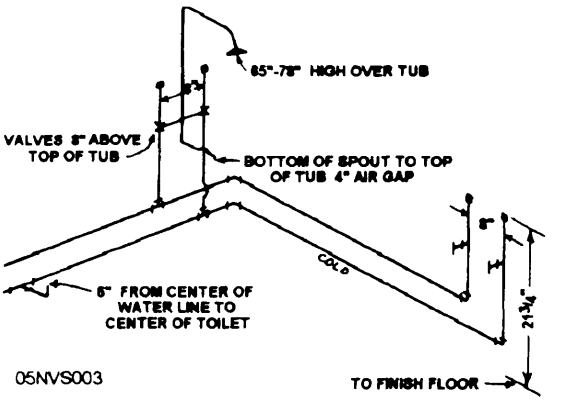

Figure 4-1(C).—Water service.

ability to read and interpret them. Imagine using only written instructions for the construction of a small building. It would take volumes of written material. Trying to understand and visualize all the details involved in a construction project would present a very difficult problem for anyone. For this reason, prints are used. They are also used by the supervisor to monitor the progress of construction.

You must be able to interpret the details, perform the work, and follow directions from these drawings. You must be capable of reading prints and passing along the information contained on the drawings. Figure 4-1(A) shows a typical bathroom. Compare the relationship between the views in figures 4-1(B) and 4-1(C) with 4-1(A)

BLUEPRINT LANGUAGE

There are various ways that a blueprint shows work to be done. Since the written word can be confusing and take up valuable time and space, other means have been developed. These means include various types of lines, symbols, abbreviations, and other methods of providing dimensions and working directions.

TYPES OF LINES USED ON DRAWINGS

The main types of lines a Utilitiesman should be able to read and understand are depicted in figure 4-1(D).

ELECTRICAL SYMBOLS AND ABBREVIATIONS

In addition to using different types of lines, both the architect and the engineer's intentions are communicated through the use of symbols and abbreviations. In the preparation of electrical drawings, most engineers use symbols adopted by the American National Standards Institute (ANSI).

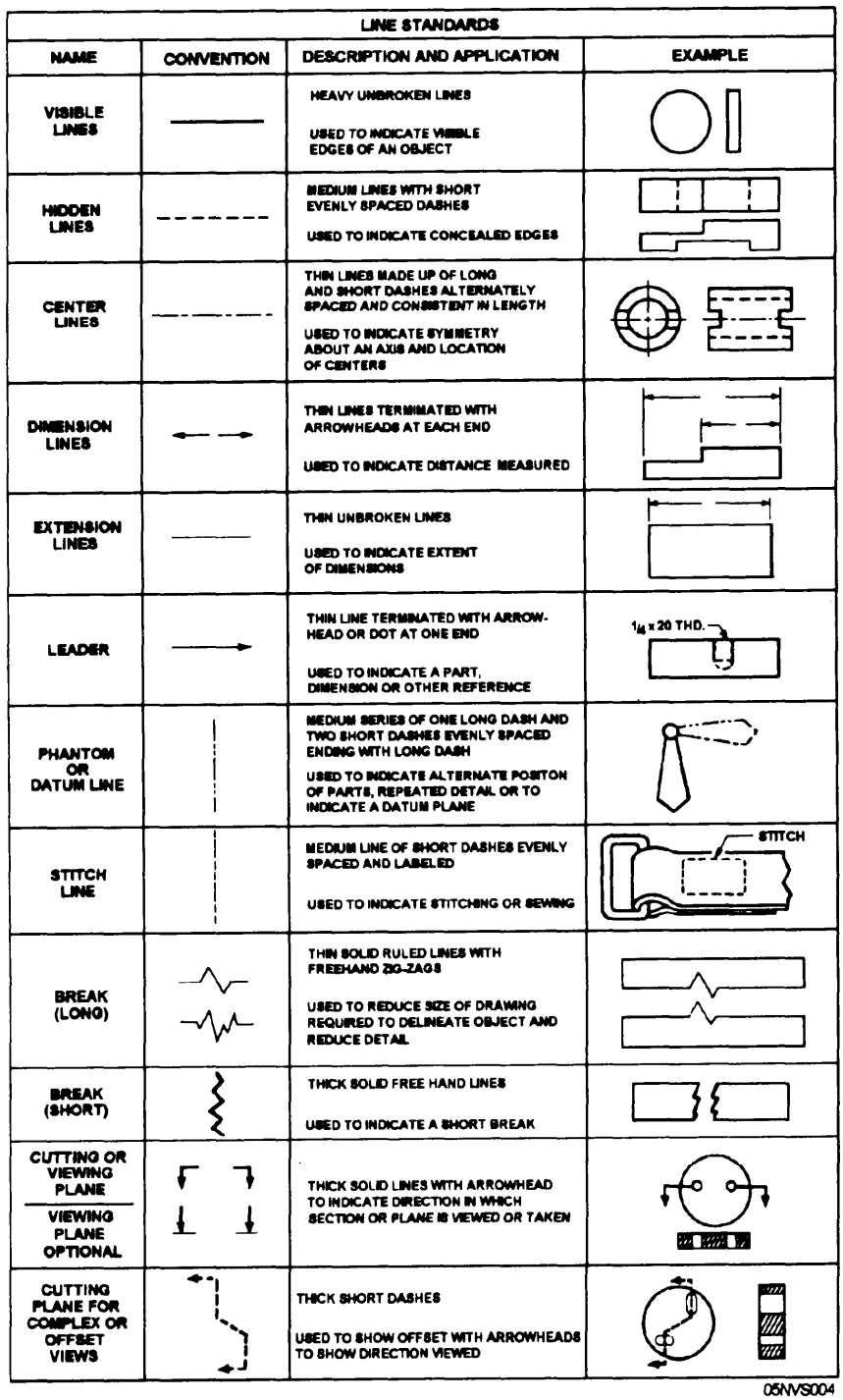

Figure 4-1(D).—Construction drawing lines.

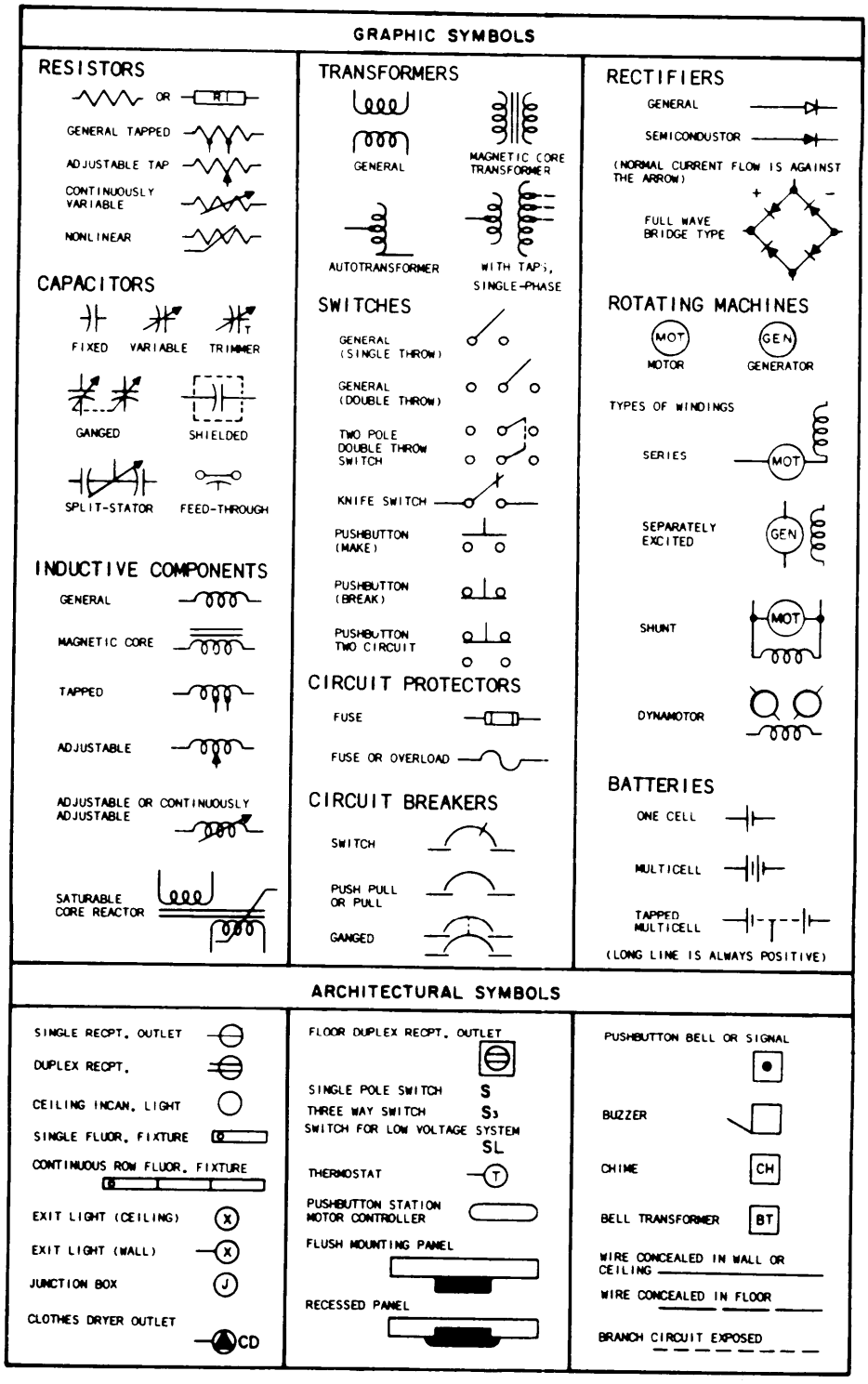

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Figure 4-2.—Electrical symbols.

(ANSI). However, many engineers will modify them to suit their needs. For this reason, most drawings have a symbol list or legend. The electrical symbols in figure 4-2 are taken from the ANSI Y32.9, 1972 publication.

CONSTRUCTION DRAWINGS

With a thorough knowledge of blueprint language (symbols, abbreviations, and lines), you will be able to extract the information that is provided on the different prints. Types of construction drawings you should be familiar with are discussed in the following sections.

Plot Plan

The plot plan is the starting point for any building that is to be constructed. It shows where the building is to be placed on the plot of land or property and shows the shapes and dimensions of the plot. When the plot plan is bounded by streets or drives, such information is also shown.

The plot plan aids the Utilitiesman by showing the point where the service taps from a main are to be connected or what route the pipe will need to be run for an underground service.

Exterior Elevation Drawings

The exterior elevation drawings show views of the finished exterior sides of the building. They show exterior trim, finish, window and door openings, roofing, and brickwork. Finished grade lines and floor lines are also shown. You may find this information helpful in locating outside wall hydrants or hose bibs.

Interior Elevation Drawings

The interior elevation drawings show views of inside wall space that contain counters, sinks, cupboards, and other special features. These drawings can be of great help in determining where to place rough-in piping for water or drainage systems in kitchens and bathrooms. The material that is to be used for walls also affects the distance from the finished wall that the through floor drainage or water supply will be roughed in to (water closets, floor drains, and so forth).

Sectional or Detail Drawings

Sectional or detail drawings are often inserted into drawings to show a specific detail. They may be a cross-sectional view of the building supports or foundation. They could be used to show story height and ceiling height. They may be used to show what floors are made of, whether they have wooden joists or some other type of construction. Any of these factors might influence the method of doing mechanical work and the kind of material that is to be used.

Floor Plan

A floor plan drawing is used to show exactly what the name implies, a plan of the floor. The drawing includes the layout of all interior and exterior walls, including windows and doors. It also shows all fixture requirements. A typical floor plan is shown in figure 4-3.

All the drawings mentioned thus far are proportional reductions of the final structure. The amount of reduction depends on the size drawing desired. Dimensions in feet are reduced to parts of an inch; for example, 1 foot may be reduced to 1/4 inch or 1/8 inch. The reduction is called the scale of the drawing. If the scale of a drawing is 1/4 inch = 1 foot, a 1-inch line would represent 4 feet on the actual structure.

BILL OF MATERIAL

A bill of material (BM) is a tabulated statement of the material required for a given project. It contains information such as stock numbers, unit of issue, quantity, line item-number, description, vendor, and cost. Sometimes the bill of material will be submitted on either material estimate sheets or material takeoff sheets; each contains similar information. Actually, a bill of material is a grouped compilation based on the takeoffs and the estimates of all the materials needed to complete a structure. Usually, the takeoff sheet is an actual tally and checkoff of the items shown, noted, or specified on the construction drawings and specifications.

Most NAVFAC drawings will contain a bill of material incorporated within the drawings. But, there are times when you are directed to tabulate materials needed for a new project that has been designed in-house for cost estimating and funding.

ELECTRICAL WIRING AND MECHANICAL DIAGRAMS

You will be working with mechanical equipment thta requires electrical connections. Therefore, you should maintain close liaison with the Construction Electrician who will involve you in working with electrical diagrams as well as mechanical mechanical drawings. This section discusses types of electrical diagrams and their usage, as they apply to a Utilitiesman.

An “electrical diagram” is defined as a line drawing that shows the arrangement and/or

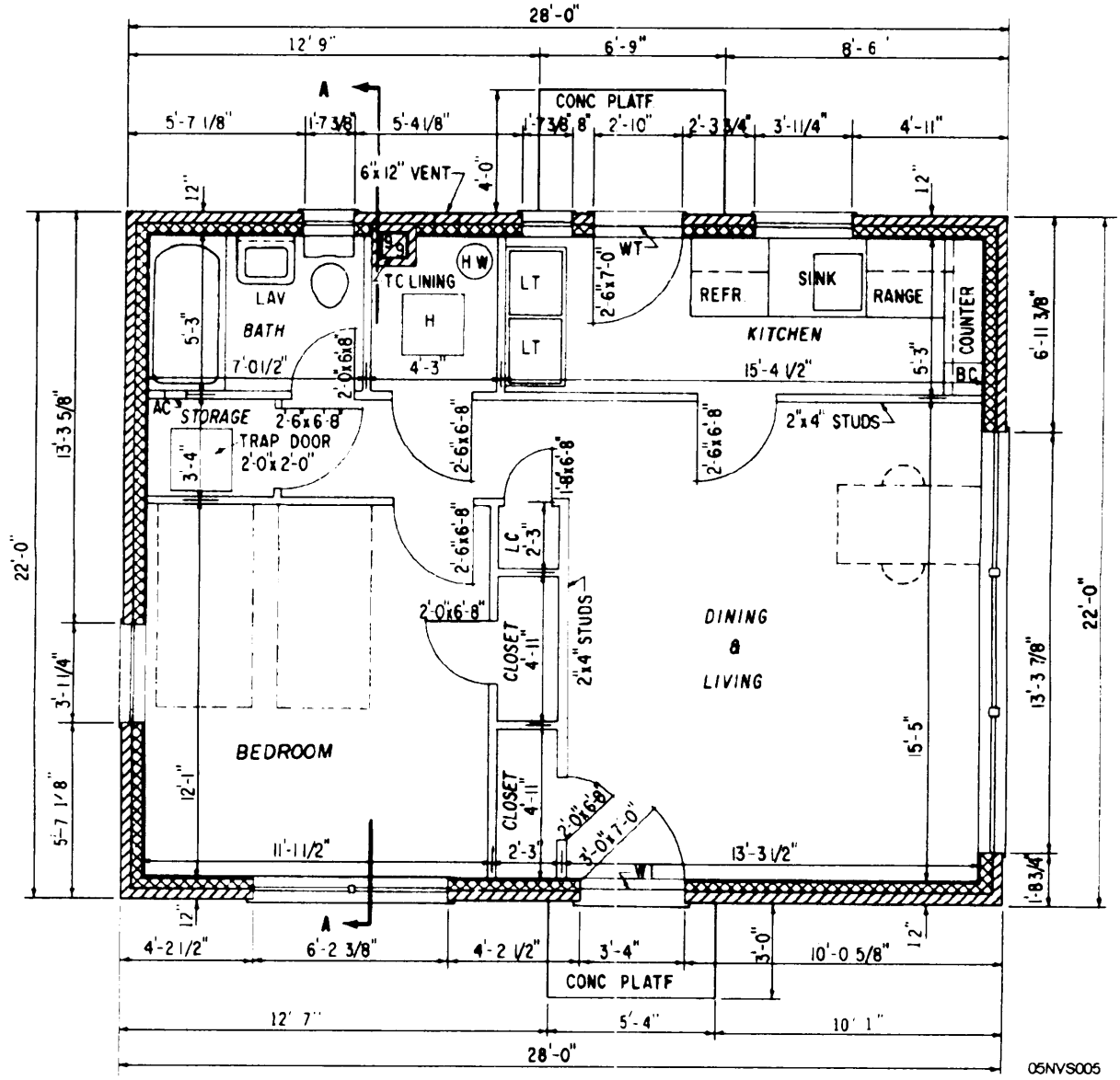

Figure 4-3.—Floor plan.

relationship of parts. Electrical diagrams are usually used to show how the parts of a piece of equipment or several pieces of equipment are wired together. These diagrams are similar to each other. Their names are sometimes used interchangeably, but they do have differences.

The types of diagrams with which you will be working are covered below. The short description of each should enable you to recognize the different diagrams.

ISOMETRIC WIRING DIAGRAMS

The isometric wiring diagram is not used very often in electrical work. When used, it shows the electrical relationship in multilevel buildings, between floors, or the total electrical system. In the isometric diagram, the cable and fixtures are shown only in their general location. Their exact locations are given in the electrical prints. (See fig. 4-4.)

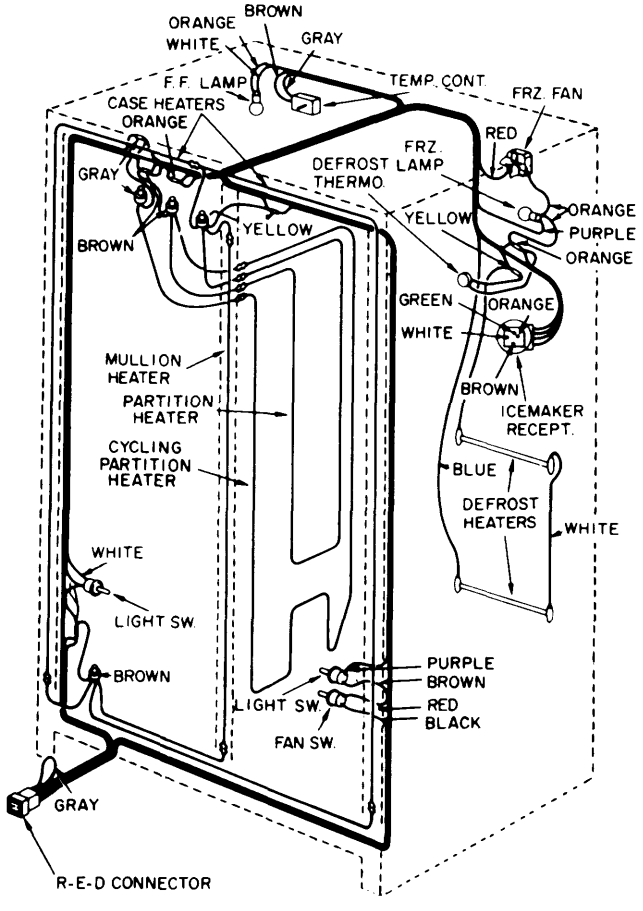

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Figure 4-4.—Schematic wiring diagram of side-by-side refrigerator with automatic ice maker.

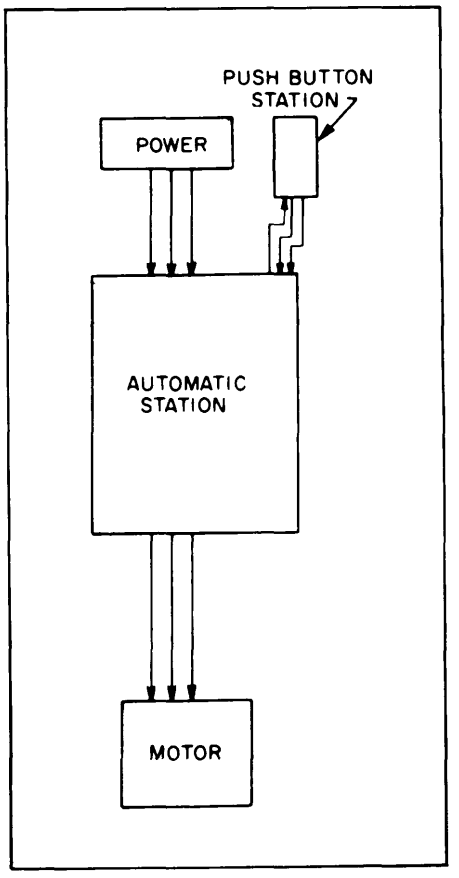

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Figure 4-5.—Block diagram.

A block diagram is a simple drawing showing the relationship of major parts of a system. Figure 4-5 shows a block diagram of a motor control system. You can easily see why it is called a block diagram. The parts or components in any block diagram will be shown just as they appear in this drawing, as blocks. They are then connected by a line or lines that show the relationship of the parts. The internal connections of the components are not shown in these drawings. The blocks are simply labeled to show what each represents. These drawings would be of little help for troubleshooting.

WIRING DIAGRAMS

The wiring diagram, which is like a picture drawing, shows the wiring between components and the relative position of the components.

Figure 4-6 is a wiring diagram of the same motor control system shown by the block diagram. You can see that instead of blocks being used to show components, a picture of the component is used. You can also see that the lines used to show the wiring are marked with numbers or letter-number combinations. Lines L1, L2, and L3 are incoming power leads, and the diagram shows the terminals in the starter to which they are connected, Wiring diagrams are often used along with a list of repair parts and are helpful in troubleshooting problems.

CONNECTION DIAGRAMS

Figure 4-7 is a connection diagram. It makes use of diagram symbols instead of pictures to show components. It also shows all the internal and external circuit connections. These connections can be read and traced more easily than on a wiring diagram. In the connection diagram, the components are still shown in their relative positions. This diagram may be used when you are connecting the wiring or tracing any part of the circuit. Remember that the connection diagram is a valuable troubleshooting tool. It is often found inside the cover of a piece of equipment. The dotted line indicates a single component.

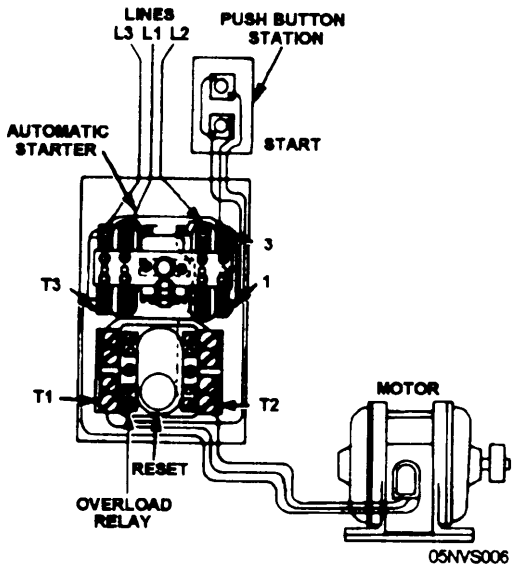


Figure 4-6.—Wiring diagram.

SCHEMATIC/SINGLE-LIINE DIAGRAMS

The schematic diagram is a drawing that shows the electrical plan of operations of a piece of equipment or component. The relative position of parts is not shown in this type of diagram. The schematic diagram, like the connection diagram, makes use of symbols instead of pictures. The schematic shown in figure 4-8 is a plan

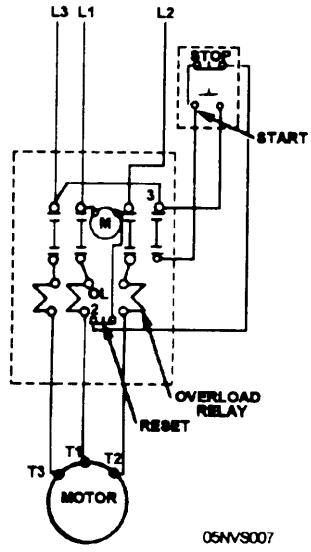


Figure 4-7.—Connection diagram.

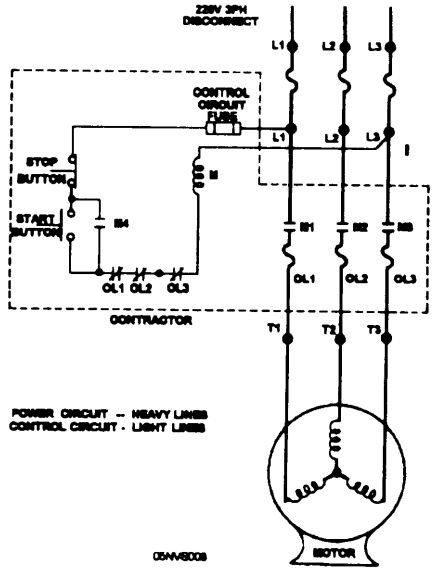


Figure 4-8.—Schematic diagram.

of the same motor control system shown in the other three diagrams. It is laid out so the process of operation is easy to trace. The schematic is sometimes called an elementary or a single-line diagram. It is also useful for troubleshooting purposes.

OPERATION PROCESS

To understand the electrical operation of figure 4-8, you must be able to identify all of the components in the figure. L1, L2, and L3 are the three phases of power. The control circuit fuse is placed in the path of the beginning of the control circuit. Therefore, when excessive current is drawn through the control circuit, the fuse will blow and open the path. The M coil is located in the control circuit, which, when energized, changes the position of contacts labeled with an M. OL1 and OL2 are in-line fuses in the load circuit which protect the motor. When OL1 or OL3 opens due to excessive current or too much heat, contacts OL1 or OL3 open, causing the M coil to be de-energized. Follow the logical sequence in table 4-1. It shows the electrical operation of this simple, but actual design, you will see in the field.

Table 4-1—Three Phase Motor Controller Circuit

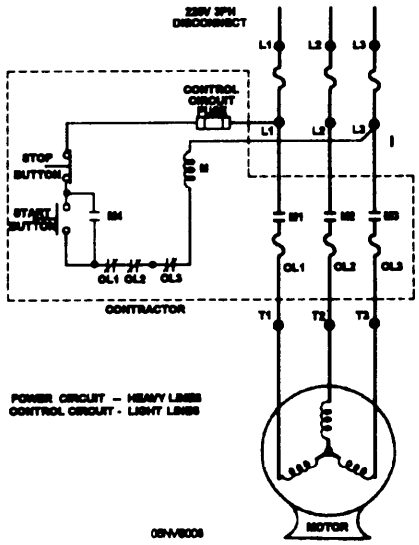
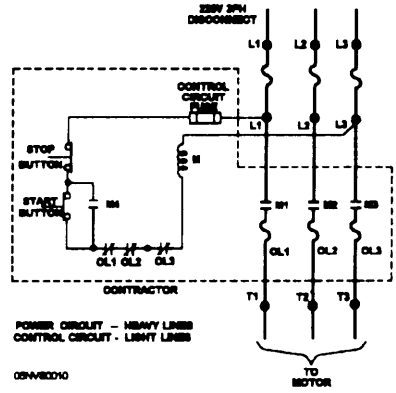
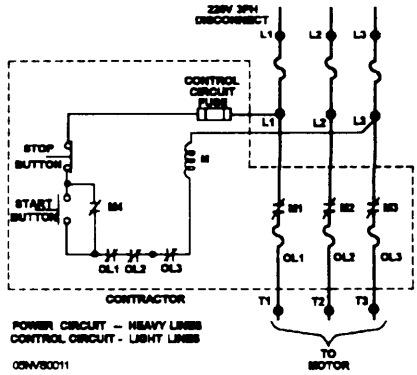
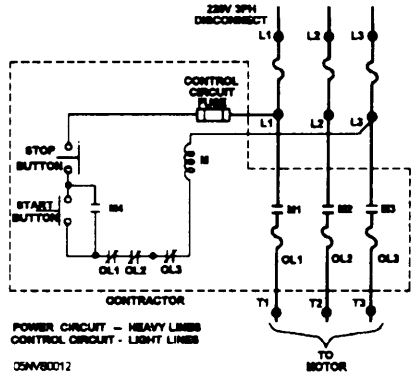
MANUAL ACTION	CONDITION	ILLUSTRATION
None	Voltage is present at L1, L2, and L3. The path extends to the top of contacts M1, M2, and M3. L1 is providing voltage through the control circuit fuse and the stop button. The load (motor) will not operate at this time.	

Table 4-1.—Three Phase Motor Controller Circuit—Continued

MANUAL ACTION	CONDITION	ILLUSTRATION
Start button is pushed	Current flows through the path from L1 through the control circuit fuse, the stop button, the start button, OL1, OL2, OL3, and to the bottom of the M coil. L3 is providing voltage to the top side of the M coil. The M coil is energized.	
None	When current energizes the M coil, contacts M1 through M4 close, providing current to the three-phase motor. (Notice that the start button no longer provides a path for current to flow.) The path through M4 is keeping the M coil energized.	
Stop button is pushed	Momentarily, the path leading to the M coil is open. This de-energizes the M coil, and opens contacts M1 through M4.	

WORKING SKETCH

The information provided in a floor plan is limited to what fixtures are to be installed and their locations. Diagrams that show the actual layout of plumbing systems are provided in the mechanical section of the prints. Before you send a crew to put in a system and its components, draw a working sketch translating the blueprint drawings in such a way that a crew leader can use it for the installation.

A working sketch is a drawing made to express a tasking clearly and to provide a quick reference for job requirements. It should be drawn to show actual conditions on the job, the size of piping to be installed, the locations where connections are to be made, and possibly the type of joints to be used. It should also show as much detail as possible to help the crew during installationor troubleshooting. A working sketch usually shows the work you want a crew to accomplish in a selected area. It also should provide ready reference to jobsite conditions. Figure 4-3 is the floor plan of a house; it shows a bath, heater room, and kitchen. The floor plan of a structure is located in the architectural section of a blueprint package. It shows the locations of plumbing fixtures, built-in cabinets, mechanical equipment, and so forth, that are to be installed as functional components of the completed facility.

Look at figure 4-9. This is an isometric drawing of the plumbing system that services the floor plan shown in figure 4-3. It shows every detail involved in the installation, but it is not representative of actual jobsite conditions. From the isometric drawing, you can determine planning and estimating information but not the actual locations or installation

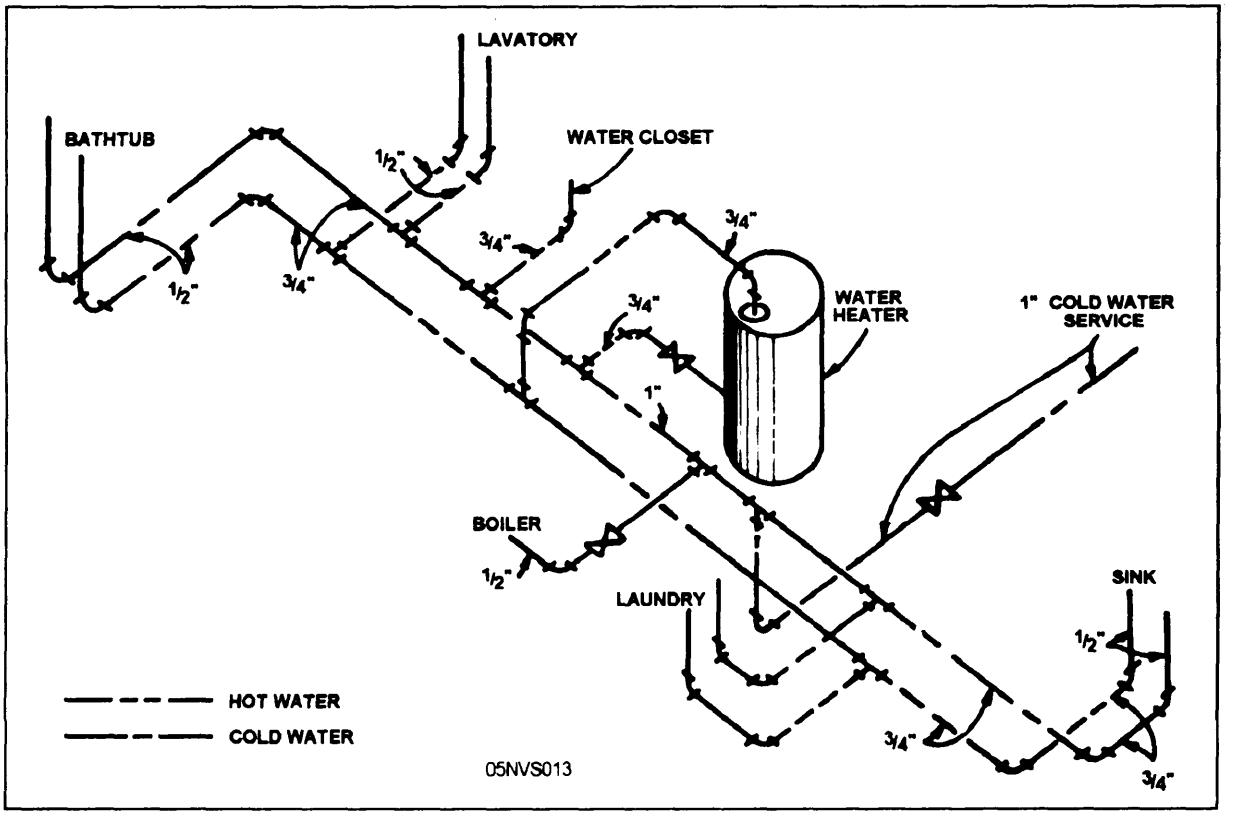


Figure 4-9.—Isometric hot-and cold-water piping system.

interfaces and problems your crew may encounter during the job.

The working sketch is something a crew should have with them while working. It can show them how, what, when, and where things happen in the sequence of a job. Your first step in making a working sketch is to draw the symbols that represent all the fixtures to be installed and locate them within the room. Try to draw them in the sequence of installation and include measurements. Now draw the piping for hot and cold water, show where it comes from and where it is going. Include pipe sizes, fittings, hanging requirements, and rough-in measurements. Do the same for the sanitary and vent systems.

The amount of detail you should use in a working sketch is determined by the crew's experience, the complexity of the system involved, and the need for interface with other trades working on the jobsite.

Working sketches are also useful to simplify complicated electrical schematics when you are installing or servicing mechanical equipment, such as air conditioners and boilers. Figure 4-10 shows electrical symbols commonly found on electrical schematics. By understanding what these electrical symbols represent, you will be able to translate the manufacturer's schematics.. By drawing a simplified working sketch of this information, you are aiding your crew in installing and troubleshooting the equipment.

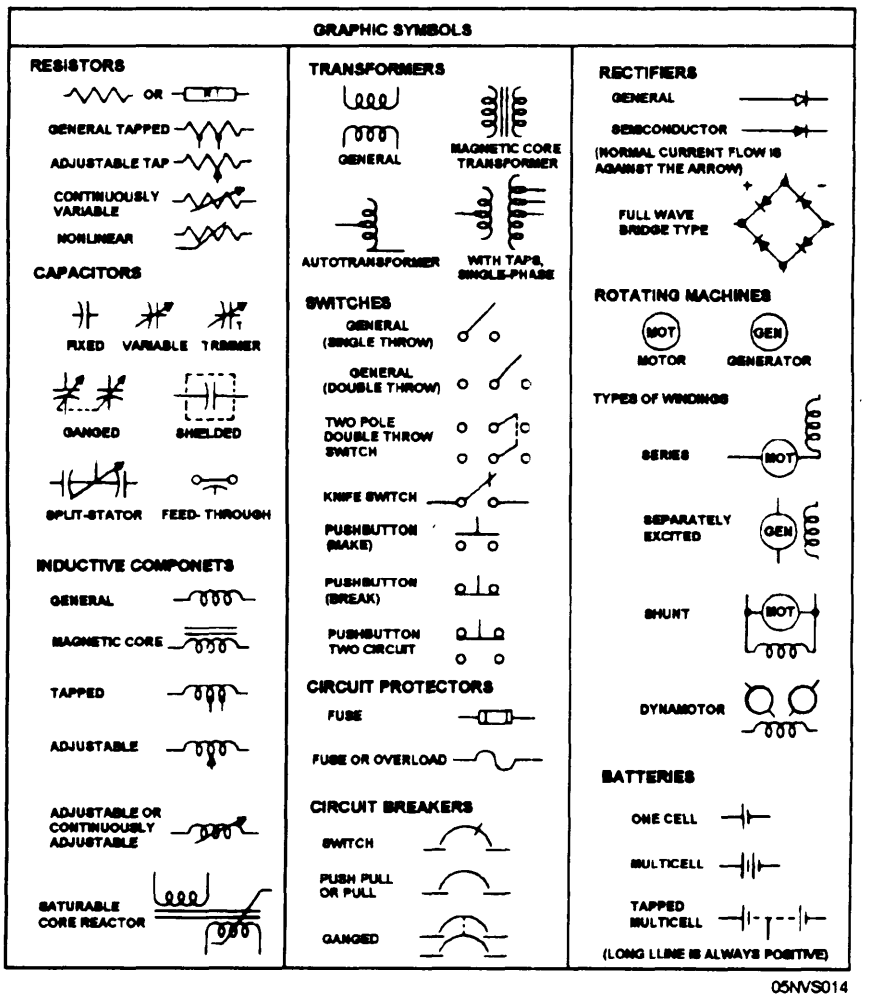


Figure 4-10.—Electrical symbols.

AS-BUILT DRAWINGS

Upon completion of a facility, the crew leader or project supervisor should provide operations with marked prints that indicate any construction deviations. The information required must show all features of the project as actually built. It is necessary for operations to review the as-built drawings after they are completed. This assures that all information appearing on the drawings shows the exact as-built conditions.

From the as-built drawings, record drawings are prepared. These drawings are the original construction drawings but are corrected according to the as-built marked print. They then provide a permanent record of as-built conditions. The original record drawings must be kept up-to-date at all times. If maintenance requires a change to the record drawing, this information should be passed back to operations or to the maintenance control division so the record print can be updated.

SCHEDULES

The schedule is a systematic method of presenting notes and information in tabular form. This makes the detailed information required easily accessible to the Utilitiesman and specifications writer. Schedules are used mostly on large projects.

A plumbing fixture schedule lists the type of fixture and identifies each one on the drawing by number. The manufacturer and catalog number of each type of plumbing fixture are provided along with the number, size, and type of fixture. A column is left for additional remarks. This Remarks column may provide such information as the mounting height above the finish floor (for wall mountings) or any other information required for proper installation. Sometimes this same information can be found in the specifications of the project, but combing through page after page of written material can be time consuming. You may not always have access to the specifications while working, but the drawings are there. Therefore, the schedule is an excellent way of providing essential information in a clear and accurate manner, allowing you to carry out your task in the least amount of time.

SPECIFICATIONS

When project specifications are prepared, they must be brief, clear, and complete. Specifications must convey the complete description of the work to be performed in a clear, concise, and coherent manner, stating the actual minimum needs of the government and the conditions known, such as site location or special construction techniques. The use of general statements should be avoided.

The specifications should be used with construction drawings to provide the Utilitiesman the needed details of a project. The drawings show the extent, size, shape, generic types of material, and the relationship between different materials. The specifications should describe the quality of materials, the installation requirements, and the method of construction. The writer of specifications should review the drawings during and after the writing of specifications. The ensures that the information appearing on the drawings has been covered in the specification and that all the requirements to accomplish the work have either been covered in detail on the drawings or described in the specifications. On the other hand, the designer or engineer should review the specifications to ensure complete coordination. Quite often, a simple detail, section, or note on the drawings makes it possible to eliminate lengthy, descriptive statements from the specification and at the same time clarify the designer's intent. Conflicts or duplications between drawings and specifications must be eliminated. The terminology used in specifications and drawings must be identical.